

Devising a Co-creative digital content development pipeline for Experiential Healthcare Education

Panagiotis E. Antoniou², Panagiotis D. Bamidis²

²Lab of Medical Physics, Faculty of Medicine, School of Health Sciences
Aristotle University of Thessaloniki (AUTH)
Thessaloniki, Greece
pantonio@otenet.gr, bamidis@med.auth.gr

Abstract.

In the medical education domain one of the core challenges in content generation is that of massive topical content. Information and Communication Technologies (ICT) have shaped interventions for healthcare and wellness from their beginning. Currently, Technology Enhanced Learning (TEL) in medicine is mostly based on case-based or problem-based learning (CBL/PBL) amongst other instructional models. TEL resources for these models include simulations, scenario narratives and other structured task-based learning episodes. A key challenge for widespread use of such experiential modalities is the rapid deployment of digital content for the extensive breadth and depth of healthcare related knowledge. This is the area where co-creative methodologies are useful. This work describes the design of a co-creative digital content development pipeline for medical education. For this AGILE development paradigms and semantic provisions are required in order to heavily modify current game development engines with specifically defined Visual Data Structures. These tools and paradigms are used to describe a specific but versatile co-creative development pipeline for experiential medical education resources. This pipeline is the precursor for a co-creative environment between healthcare professionals and developers for educationally valid and experientially rich medical education resources.

Keywords: Co-creative software development, AGILE, SCRUM, Medical Education, Augmented Reality, Mixed Reality

1 Introduction

1.1 Technology-Enhanced Learning (TEL) in experiential Healthcare Education

One of the core challenges in medical educational content generation is that of massive content for learners to absorb. It is widely documented that almost 4 decades ago medical knowledge started doubling almost every two years [1]. Educators, thus, turned to technology for coping with the volume and critical nature of content [2] with

overarching aim of such endeavors universal access to healthcare skill development tools [3].

From their founding, Information and Communication Technologies (ICT) shaped healthcare and wellness interventions. They mitigated costs and magnified capacities for growth and social equality and improved treatment and diagnostic power. Contemporary healthcare education has moved a lot towards versatile learning resources in healthcare oriented educational activities facilitated by ICTs [4]. The core motivation for this approach is the need for ubiquitous access to clinical skills development tools, unconstrained by time and place [5]. This capability of ICT in medicinal instruction is increased by the parallel progression of web advancements and the multiplication of intuitive learning situations with quick, content-related input [6].

ICT based solutions for education have been implemented in several modalities from the web [7], Multi user Virtual Environments (MUVEs) [1] and even Augmented Reality [8]. These modalities offer an inexpensive alternative to the virtual laboratory. These environments offer learner centric educational activities (e.g. repeating content, accessing it at off hours) so that students can remain motivated and engaged to the educational process. It also allows sharpening of laboratory skills beyond mere knowledge transfer. These skills mitigate core curriculum weaknesses because hands on laboratory techniques not adequately trained to students due to cost, time or safety reasons [9, 10] leaving medical students theoretical educated but lacking clinical and lab skills [10].

For these reasons the inexpensive but equally impactful technologies of virtual augmented and, recently mixed, reality (VR/AR/MR) technologies (with the advent of the Microsoft HoloLens. Evidence have been provided for these technologies increasing the impact of an educational episode, thus greatly affecting educational outcomes [11]. Examples are many including experiential world exploration [12], chemistry and physics laws visualizations that greatly impact student understanding and engagement [13, 14, 15]. The immediacy and engagement of these technologies both motivate and allows the learner to anchor, internally, knowledge about the educational material reducing the chance of maintaining conceptual errors [16]. For these modalities, the core obstacle towards widespread use is the rapid development of resources about the extensive depth and breadth of medical knowledge. This is the area where co-creative methodologies are useful in order to allow non-technical contributors (doctors or even students) to share some of the burden of content creation.

1.2 Co-creation as participatory Knowledge sharing.

The co-creation concept emerged from marketing and more specifically from product design. Value co-creation (VCC) as it was originally termed was the process for identifying an item's value offer through client participation rather than the standard statistical surveying avenues [17, 18]. In VCC, clients/users took a dynamic role and created product value together with the core stakeholder (firm, creators etc.) [17, 19]. Self-reliance, communication, engagement, and experience were identified as the key components of the joint endeavor for forming added value [20]. VCC is more than the

sum of these components as it moves past product generation to issues like product utilization and the whole chain of value delivery [17, 21]. Marketing research [22] has listed more than 27 unique definitions, that can be attributed to the two components of VCC that are termed Value in Use (ViU) and co-creation. These theoretical concepts in VCC are reinforced in earlier literature about VCC as a combining factor of buyer skills and actual cooperative firm-client product co-creation [21, 23, 24].

Co-creation offers to the product design process dynamic support for new item improvements [25, 26] in the form of co-production. Co-production involves the immediate or indirect "cooperating with clients" [27, 28] or even the applied interest in the product/service configuration process [29, 30]. Client investment may be expressed as an assistive part at the outskirts of a company's workflows [29], or in a dynamic, core part by utilizing sharing and learning of expertise and data of the firm [31, 32]. Co-creation has also been described through client association, than is by demonstrating shared physical, mental and trade activities, as well as access to common masteries [33]. Moving in more detail, co-generation has been defined as an arrangement of actions completed by actors (financial, social and others) involved in the value chain networks [34, 35]. It is implemented through coordination [36], exchange [37, 38] and incorporation of common assets into the process of value generation [39]. When clients invest assets through the co-creation forms, the key stakeholder (firm, creator) achieves both demonstrated client request fulfillment as well as exploiting client experience for the expansion of the firm [40, 41]. Co-creation also allows for the creative process to become distributed but remain within the key stakeholder a characteristic of co-production [42]. This process allows clients to be fully engaged in co-production process [43, 44] with some studies going as far as to identify value in mutualism, receptiveness, and non-hierarchical relations [32, 40] as element of co-production. This kind of extensive interpretation of the co-creation process has led research [18] to expose as one of the main factors of co-creation efficacy the sharing of knowledge.

1.3 Aim and scope of this work.

It is this exact sharing of knowledge that is tapped in the field of medical education for the co-creative effort. The target group for medical education content is the medical sector and this exact segment is also the one that has the expert knowledge that needs to be used for creation of medical education content creation. Given this incentive, it is the goal of this work to describe the design of a co-creative digital content development pipeline for medical education in order to allow digital medical content creation to keep pace with the rapidly expanding knowledge in the medical field.

2 Devising a Co-creative digital content development pipeline; paradigms and tools.

2.1 AGILE Human centric software development as the paradigm for co-creative digital content development

AGILE software development (ASD) is a software development and project management paradigm that offers on-time delivery and customer satisfaction [45]. To achieve that it deliver business value in short iterations with the development process carried out incrementally and empirically. This becomes a key advantage because direction of product development can be changed immediately. Human resources and their interactions are at the core of such methods [46]. SCRUM [47], Kanban [48] or Extreme Programming [49] are all AGILE methodologies that propose a product (usually software) development model. These models while versatile and flexible have lax definitions for what constitutes the right kind of product that maximizes customer/user needs and expectations. To address this gap for products with good user experience (UX), evolved, hybrid approaches nominated Human-Centered Design or referred User-Centered Design (UCD) [50] are applied. While there are challenges integrating ASD and UCD, their integration makes the development processes more human-centered [51]. User and stakeholder involvement is the crucial factor for such a system to succeed [52]. Compared with traditional approaches, this involvement is not only limited to early development phases, but throughout the whole development process instead [53]. Product requirements are the base of all software product development. Thus Requirements Engineering (RE) has an important role in system development. Compared to traditional approaches ([54, 55]), a list of prioritized requirements (Product Backlog [47]) is initially drafted instead of a detailed requirements specification document. The main RE activities (elicitation, documentation, validation, negotiation and management) are not an isolated stage from the rest of the development process. They are revisited in each iteration and at only iteration specific information is elaborated before moving to the next iteration. For this purpose, RE in AGILE environments is carried out just-in-time with a Little Design Up Front [56]. In this work, this just in time, integrative iteration approach is extended as a co-creative process not only for RE but also for core development activities facilitated for the co-creating healthcare professionals.

2.2 Ubiquitous game development platforms and Semantic back-ends.

The presentation part of an experiential resource for healthcare education is rather specific. It is a virtual space, overlaid to any ordinary physical space (Room, Auditorium etc.). For that purpose the capacities of modern headsets like the Microsoft's HoloLens [57] facilitate spatial mapping of the surrounding environment, allowing ubiquitous deployment of digital content in every environment. Compounding this, the advent of game development platforms like Unity 3D [58] allows for a one development- many platforms deployment. Customizability of such environments with provisions for visual data structures (e.g. Unity3D's scriptable objects [59]) is a key factor for allowing their

transformation to an editing platform that even the non-technical user can use for such specific use cases and data models.

Linkage of the specific healthcare topics to relevant TEL resources require a formal knowledge level modelling. Such a modelling requires the use of existing relevant taxonomies that concisely describe relevant medical domains as well as the development of User eXperience (UX) taxonomies that will offer hierarchies linking UI and 3D environment features with user interactions with them (collision, button click etc.). For healthcare, example of taxonomic divisions into structural and functional domains already exist in the MeSH.A and MeSH.E04 taxonomies of the Medical Subject Headings formal taxonomy [60]. Leveraging such semantic links will allow healthcare Learning Objectives and conceptual areas to easily correlate with assets used in AR/MR resources. Where no formal taxonomies exist, such experiential features will be codified in a more ad-hoc but self-consistent data level modelling way to facilitate a semantically enriched back-end.

2.3 Semantically annotated Visual Data Structures.

The data modelling of such a development endeavor would follow an approach that has been previously implemented in other platforms. Using a simple state-full node-link branching approach a narrative scenario can be implemented [61] in any 3D virtual environment (Display based, AR, VR, MR). With the same approach an exploratory educational experience can be developed using the nodes as specific stages of the exploratory experience and the links as transitions (e.g. through buttons or location triggers) between each stage of the learning experience. The overall functional design of the Visual Data Source is outlined in **Fig. 1**. Specifically, the VDS is an object that contains several attributes that are programmatically accessible. These would include things like a 3D model with or without animation, text narrative or descriptions. It would also include data modelling information like the role of this asset

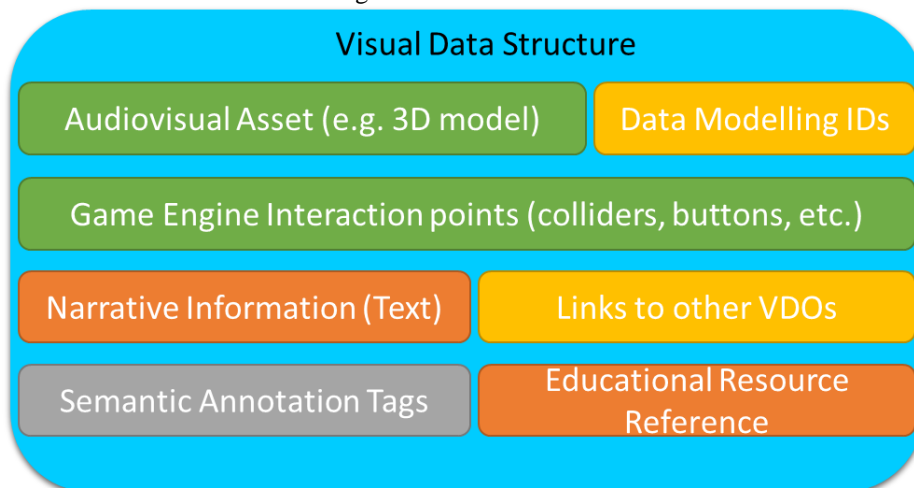


Fig. 1. Visual Data Structure Internal Design.

in a specific educational resource, complete with links from and to other such resources, including the graphical points of interaction (colliders, buttons etc.) of the 3D resource. This VDS when annotated through custom or existing taxonomies is easily usable from a non-expert (she can easily search through a repository of such resources, find, explore them and finally edit the narrative details to fit her new purpose). It is also readily understandable by a non-technical user about its use. The user can drag and drop these visual resources together and through preprogrammed provisions to express narrative or exploratory links between them directly in the 3D environment. That way a complete resource can be prototyped completely by the co-creating user without intervention from technical experts. The technical experts' job will be to facilitate the process by creating completely non-existent 3D assets when pre-existing solutions are not adequate and coding unexpected interaction requirements from the co-creating user.

3 Proposing a Co-creative digital content development pipeline

The previously described methodologies and tools are distilled in a specific content development pipeline. The base of the methodology in this endeavor will be flexible scheduling of software and 3D model resource iterations based on several SCRUM pushes as defined in the SCRUM, AGILE development framework [47, 62]. The details are presented below. Throughout this section professionals specifically oriented in technology resource development (coders, 3D artists etc.) are referred to as “the development team”, “developers”, or “the technical team”. On the other hand, topical experts, co-creators, such as doctors, students, or other healthcare educators will be referred to as “co-creating users”, “co-creators” and “domain experts”.

Preparation and Planning Stage

This stage consists of the co-creating users' acclimation and introduction to the methodology and tools of the pipeline. This would take the form of a short workshop that will bring all the participants to the required readiness level for using the co-creative infrastructure. Planning also will include well defined roles allocation. For each resource or group of resources the domain experts will be defined not only as a co-creator in the pipeline but also as a formal product owner in the SCRUM role scheme [62]. This will allow the development team to have focused guidance through familiar roles.

Co-creation Stage

Access to the co-creative infrastructure is provided and the participants agree to a deadline for completing their content. At all the time of the co-creation stage the users shall have access to technical advice from the technical team that is also gathering the required content that needs to be originally developed.

Technical Facilitation Stage

The Technical Team develops the necessary content and the co-creating users approve it. In this stage, completely new, required, resources will be developed. This

means that several iterations of the 3D models will be developed digitally from medical 3D artists and interaction template that are not covered from existing resources will be devised by the programming technical facilitators. All resources will be reviewed by the respective product owner before committing to releasing the resource for integration in the specific educational episode.

Prototyping Stage

The resource is deployed and explored. Educational alignment of the resources will be verified through trial runs and evaluated through users' focus group sessions. Bugs, issues and content issues are identified for the next pass of the resource through the pipeline.

4 Discussion

The proposed pipeline in this work has been designed in a twofold manner. On one side care was taken to design the supporting data structure and toolkit as generic as possible, while on the other side achieving ease of use and co-creative versatility by incorporating in it the core provisions of experiential medical education prevalent use cases. This co-creative pipeline of course needs to be tested and verified both for development efficacy and educational content value.

Preparatory work by the developers is required for offering a toolset that removes technical overheads and allows the co-creating user to quickly put together her concept to the platform. Most of the content development platforms (e.g. Unity3D) are powerful and versatile enough to allow for deep customization. This type of customization by technical experts can transform these programming environments almost completely into graphical design environments that are easily usable by non-technological users. These solutions and the co-creative process is also facilitated as the generations shift from technology illiterate towards not only technology literate but technology natives [63]. This shift in the co-creator's demographic towards people who are familiar not only with the use of technology but also with basic programming concepts (branching-looping etc.) and thus they can become even more autonomous in content co-creation. With most aspects of technology going towards a user-centric design paradigm [50], this work is the initial step for a co-creative environment between healthcare professionals and developers that can both focus on educational veracity and ensuring rich experiential resources.

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